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# ELECTRIC RANGES

BY

C. W. PIPER

BULLETIN NO. 2
ENGINEERING EXPERIMENT STATION

Monograph

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BULLETIN NO. 2

# ENGINEERING EXPERIMENT STATION

# ELECTRIC RANGES

BY


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PURDUE UNIVERSITY

LAFAYETTE, INDIANA

MARCH, 1919

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# PREFACE

The object of this bulletin is to present the characteristics of the different types of electric ranges, also data on the cost of baking with electricity.

The work was conducted by Mr. C. W. Piper, Instructor in Electrical Engineering, and Mr. H. W. Asire, Research Assistant, Engineering Experiment Station, under the direction of Professor C. Francis Harding, Head of the School of Electrical Engineering, Purdue University.

The Home Economics Department, under the direction of Professor Mary L. Matthews, co-operated extensively in the operation of the ranges and offered valuable assistance and advice in connection with the cooking tests. The following students assisted at different times with the work as a part of their theses: Miss Helen Virginia Hendey, Messrs. R. B. Stein, E. W. Tatman, F. H. Crosby, J. M. Naylor and K. A. Rarick.

The work was made possible through the courtesy of the Hotpoint Electric Heating Company, Ontario, Cal.; Rutenber Electric Company, Marion, Ind.; Standard Electric Stove Company, Toledo, Ohio; Hughes Electric Heating Company, Chicago, Ill.; Estate Stove and Range Company, Hamilton, Ohio; Westinghouse Electric & Manufacturing Company, East Pittsburg, Pa., and the Globe Stove and Range Company, Kokomo, Ind.

# ELECTRIC RANGES

## INTRODUCTION

The year 1890 or 1891 may be taken as the date which marks the first practical attempt to make electrically heated cooking apparatus. In the early days there were many technical difficulties to be surmounted by the pioneers in electric cooking but these have been gradually overcome.

In 1891, Mr. H. J. Downing, one of the pioneers and founders of the Downing Radiant Heat Company, exhibited electric cookers and heaters, at the Crystal Palace Electrical Exhibition.

In 1895, Col. R. E. Crompton read a paper before the Society of Arts on the use of electricity for cooking purposes. He also showed a large variety of cooking appliances and their uses.

The American engineer and manufacturer have made rapid advances and contributed many valuable ideas in the electric cooking field, from as early as 1896.

Mr. A. F. Berry placed on the British market, in 1908, the "Tricity" cooker. The design was quite similar to the oven of today. Many thousands of these cookers are now in daily service and are generally giving satisfaction.

The progress of electric cooking in America has been retarded for several reasons, chief of them being the high cost of the apparatus and of the energy. However, the advantages of cooking with electricity are fast being recognized.

There are now on the American market many types of electric cooking apparatus, some quite novel in conception and design. Complete equipments for electric cooking have been placed and are now in use in hotels, hospitals, colleges, convents, schools, club buildings, restaurants and other large establishments in America, England, Canada, Australia and other countries. Railways, large steamships and war vessels are using electricity for cooking as well as for lighting and motor power.

Each step from cooking by the open fireplace, to the coal stove, gas and electric range has been marked by the use of more expensive fuel, greater heat efficiency, better temperature control, and more satisfactory food.

There are three reasons for cooking food:

1. To make it more digestible.
2. To improve its appearance and flavor.
3. To sterilize it and so arrest or prevent chemical change.

Usually all three results are attained as in baking bread, where the raw starch is cooked to a more digestible form, the yeast plant is killed, preventing the bread from spoiling and the attractiveness is increased many fold.

**Fig. 1. Range No. 1. Open type heating units.**

The electric fireless cooker range is well adapted for obtaining the above results. It has close temperature control which makes slow, thorough baking possible and produces more digestible food. A quick rise in temperature provided at will gives a nice even brown in a few minutes.

The use of electricity for cooking will become even more popular as the cost of energy is reduced. The energy rates throughout the country are in general so high that electric cooking is possible only to those who can afford luxuries, and until the rates are reduced for cooking purposes, electrically heated stoves will be barred for the kitchen of the average family.

**Fig. 2 Range No. 2. Surface burners, porcelain type. Oven heating units, open type.**

It has been found that at three cents per kilowatt-hour the housewife who operates a modern electric range can cook as economically as one who uses a gas range and pays one dollar per thousand cubic feet of gas. In analyzing the prices at which current is offered for electric cooking in the United States, the interesting fact

is revealed that in the Eastern and Western States, the rates average less than four cents per kilowatt-hour, while in some central localities where water power is available or coal is cheap, energy is supplied for as low as two cents per kilowatt-hour.

**Fig. 3. Range No. 3. Surface burners, enclosed type. Oven heating units, open type.**

The comparison and conclusions drawn in this bulletin are based upon the rate of three cents per kilowatt-hour which is the flat rate advised by the National Electric Light Association.

## THE ELECTRIC RANGES

The ranges used for this investigation were:

Globe Electric Range ........................Serial No. E1
Westinghouse Electric Range .................Style No. 240603
Estate Electric Range ........................No. 84
Hughes Electric Range ......................Style No. 50
Standard Electric Range ....................Model No. 601
Hot Point Electric Range ....................Model D
Rutenber Electric Range ....................No. 1058

The order in which these ranges are given above has nothing to do with the numbers by which they are referred to later.

These stoves represent the best types of modern American electric ranges. All are of the cabinet design, except range No. 7,

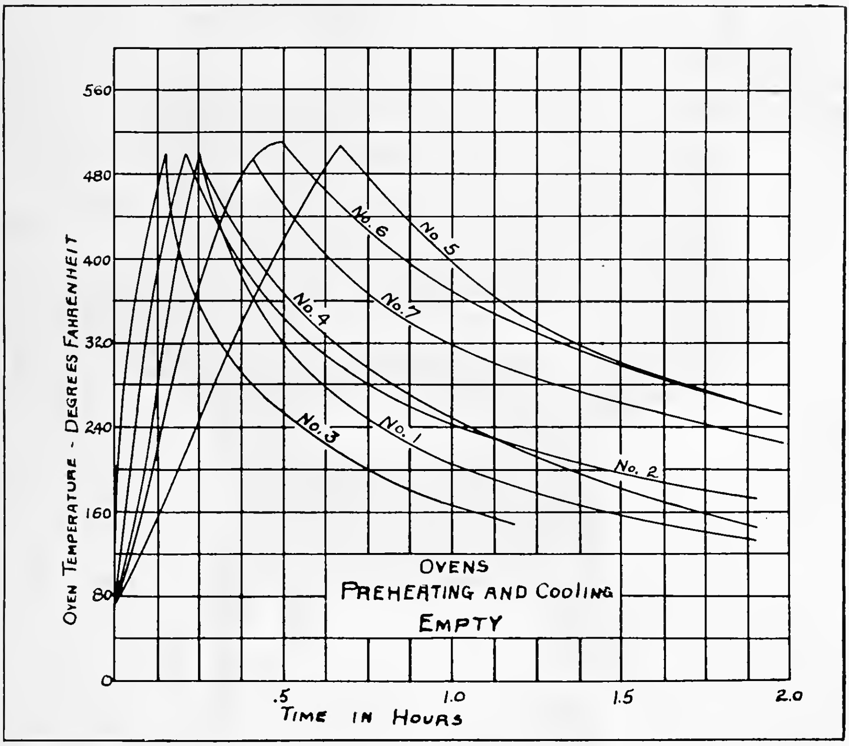


Fig. 4

which has its oven below the surface elements. The detailed description of the ranges will be found at the end of the bulletin.

## ELECTRIC OVEN TESTS

The ranges were tested under conditions such as are found in the home, except, that rated voltage was impressed upon each range

and kept constant while in the home the voltage is somewhat variable.

The temperatures of the ovens were measured by calibrated copper-advance thermocouples, and milli-voltmeters. The thermocouples were placed as near the center of the ovens as conditions would permit.

The tests were divided into six classes as follows:

1. Preheating and cooling with ovens empty.
2. Preheating and cooling with three pounds of water in each oven.
3. Temperature indicator calibration.
4. Open door test.
5. Oven insulation tests.
6. Baking tests.

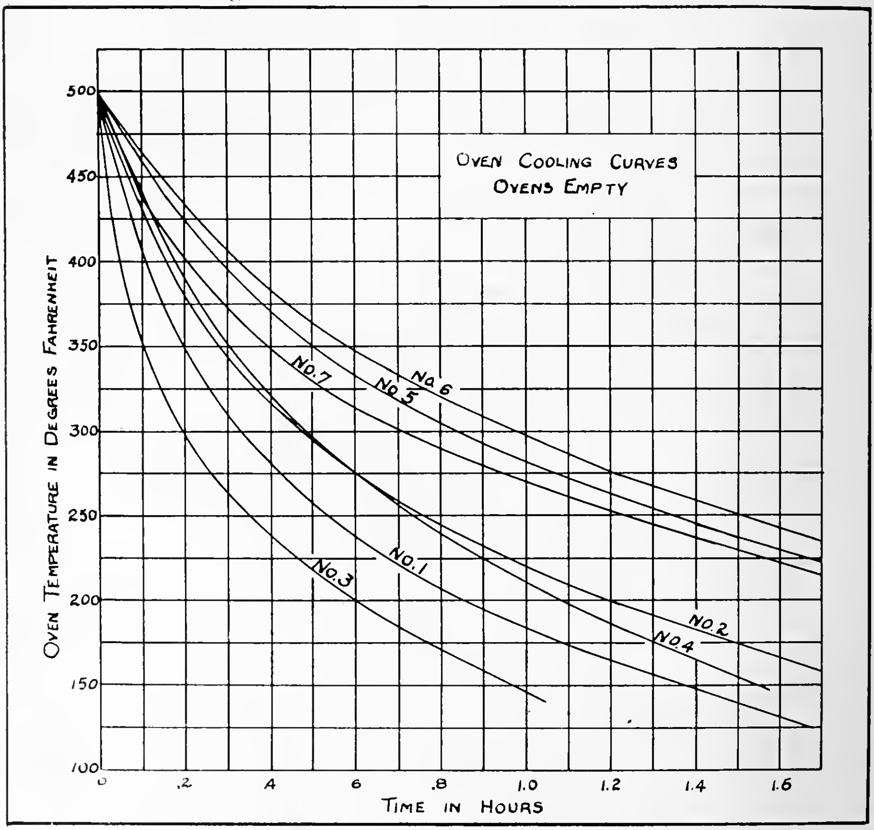


Fig. 5

Of the various tests the preheating and cooling tests with empty ovens will be first considered as they determine the time and energy

required to bring the ovens up to baking temperatures. These were made by supplying maximum current input to the empty oven. When the temperature reached 500°F. the current was turned off and the oven allowed to cool at its natural rate. Power input in watts and temperature readings were observed at five minute intervals.

Curves of these tests will be found in Figs. 4, 5, and 9.

The tests with water in the ovens were made by placing a wide top pan containing three pounds of cold water in the cold oven and heating until the water boiled. These tests were made to determine the time and energy required to heat the ovens when baking starts at room temperature. Two thermocouples were used in each oven. One measured the oven temperature and the other that of the water. The placing of water in the oven tended naturally to increase the preheating time and to decrease the cooling rate. The results of these tests are given in Figs. 6 and 9.

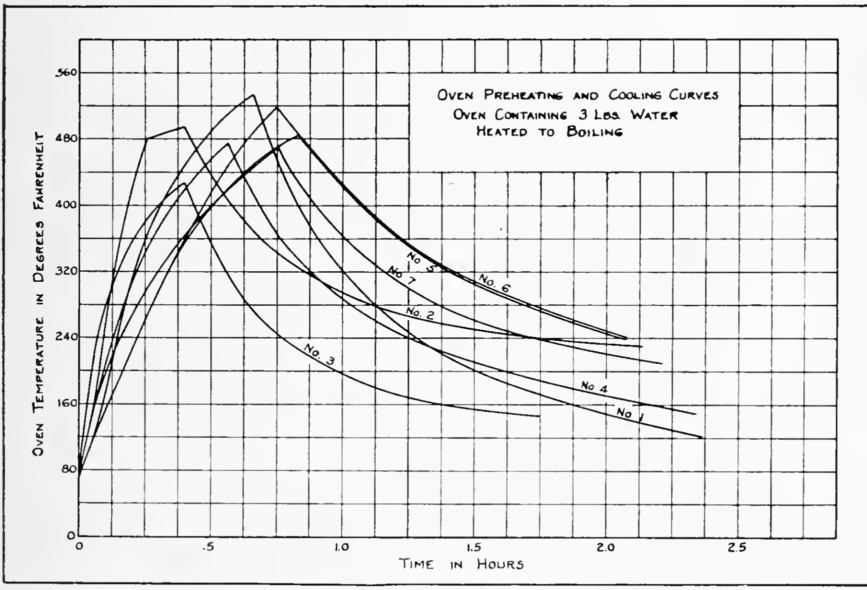


Fig. 6

While conducting the preheating tests, the performance of the oven door temperature indicators was observed. These thermometers all had about the same lagging characteristics as the one shown in Fig. 9.

The temperature decrease and consequent loss of energy due to opening the oven doors, for short periods, was determined. The ovens were brought up to the desired temperature and at intervals of two minutes and three quarters the doors were opened for

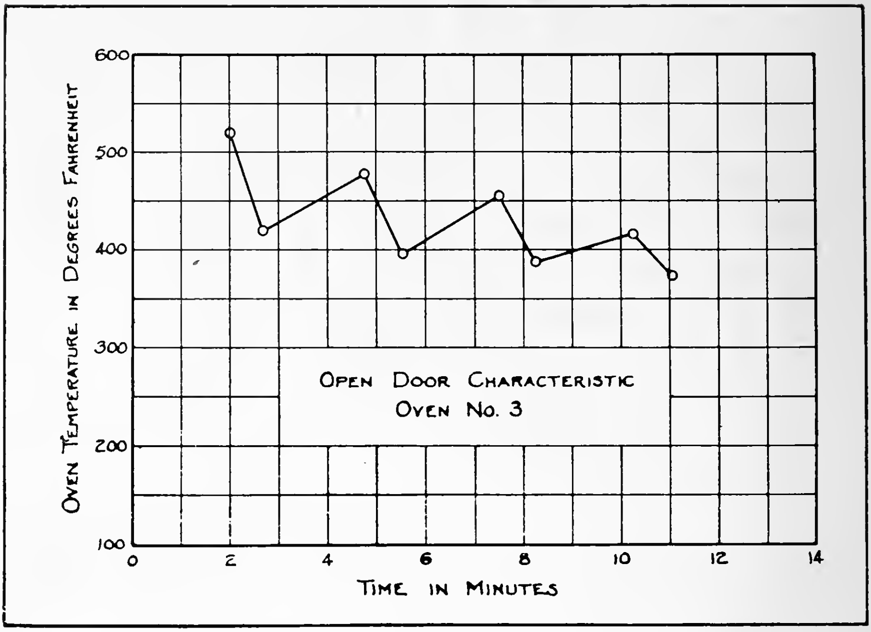
600
500
400
300
200
100
0
2
4
6
8
10
12
14
Oven Temperature in Degrees Fahrenheit
Time in Minutes
Open Door Characteristic
Oven No. 3

Fig. 7

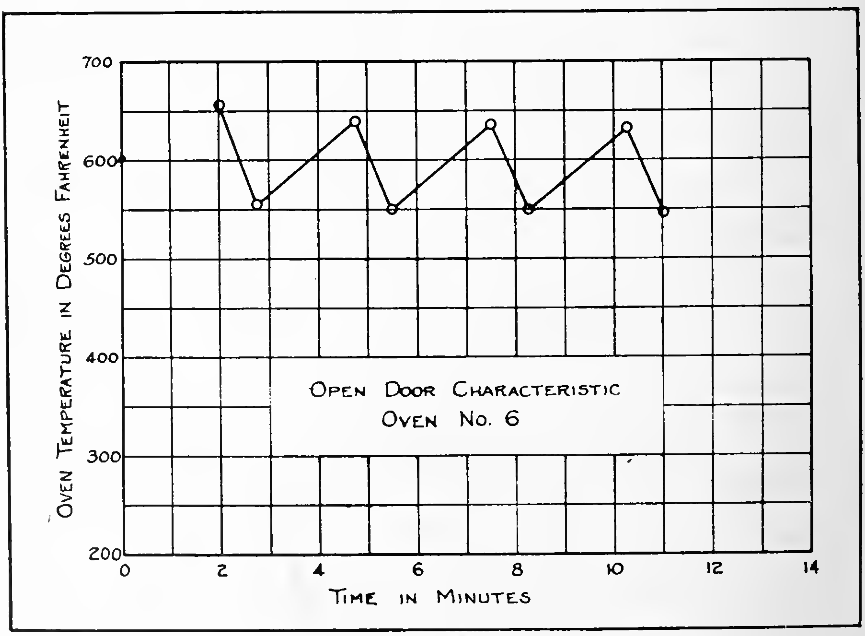
700
600
500
400
300
200
0
2
4
6
8
10
12
14
Oven Temperature in Degrees Fahrenheit
Time in Minutes
Open Door Characteristic
Oven No. 6

Fig. 8

three quarters of a minute. All readings were taken at the time of opening and closing the doors. During the entire test the power input in watts was maintained constant. Figs. 7 and 8 show the cooling effect of open oven doors.

The heat insulation property of the oven walls, was obtained by adjusting the power supplied to the oven to a definite value and allowing the oven temperature to rise until it became constant. The time required for this varied from 1½ to 7 hours. Fig. 10 shows the radiation from each oven throughout its working temperature range.

## RESULTS OF OVEN TESTS

Preheating (ovens empty): The energy input during the preheating run was a maximum for each oven except No. 5. This range was run on medium, so as to have the watts input approximately the same as the other ovens. This caused its preheating time to be increased.

It will be noted that Range No. 3 with its small oven and large heating units became hot the quickest, reaching 500°F. in nine minutes. Range No. 5 which has a heavy steel lining, heated most slowly. However, credited to this range is a slow cooling rate, while No. 3 cooled most quickly.

The cooling rates taken from the previous tests are shown on Fig 5. Here it is noted that range No. 6 was the slowest to cool. The general oven dimensions and appearance would not indicate that its cooling rate should be superior to all others.

Preheating (ovens filled): The effects produced by water in the ovens were quite noticeable (Fig. 6). In three instances it altered the position of the curves. Peaks of the curves for ovens No. 1 and No. 3 were shifted toward the others. The general tendency seemed to be to group the curves more closely, only partially overcoming, however, the dominant oven characteristics.

Open Door: The characteristic curves for opening doors show that oven No. 3 cooled quickly. During the three quarter minute of open door, an average temperature decrease of 75°F. occurred. In the following two minutes, when the door was closed the temperature increased 50°F., there being 25° net loss in temperature. Oven No. 4 corresponds very closely to that of No. 3, the total drop for the test being 70°F. Ranges No. 5 and No. 6 maintained a constant heat, even though their temperature was about 100° higher than No. 3, that is, the two minute period during which the doors were closed, was sufficient to allow the oven to recover the heat lost, while the doors were open.

The ovens lined with heavy material cool more slowly, when the doors are open, than the small ovens constructed of lighter weight material.

Temperature Indicator: The oven temperature indicators have a tendency to lag behind the oven temperature changes. Fig. 9 shows a characteristic indicator temperature curve. They register less than the true oven temperature because the oven door temperature is lower than the temperature of the air inside the oven.

The most satisfactory indicator tested was that on range No. 7, which followed closely the oven temperature changes. Its calibration closely approximated actual temperatures expressed in degrees Fahrenheit.

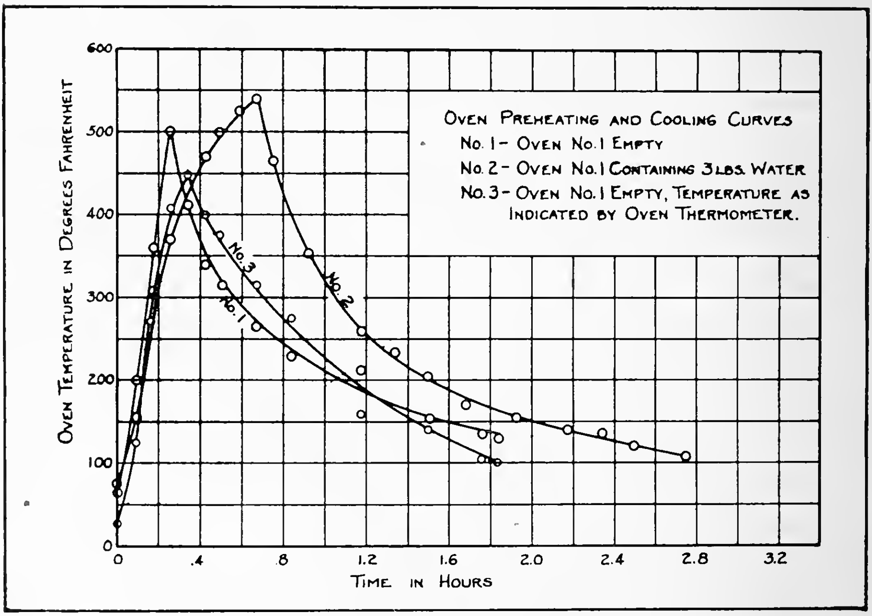


Fig. 9

Oven Insulation: Ranges No. 1 and No. 4 required the greatest amount of energy while range No. 6 consumed the least. The other ranges consumed about the same amount of energy.

The oven of range No. 1 has thin walls and a poorly fitting door, and the losses are great through the thin non-insulated bottom to the warmer oven.

The oven of range No. 4 is large, but the reason for the loss of heat in this oven could not be determined by inspection. The door catch was of poor design and possibly the heat insulating material of the walls was not of the best quality.

The construction of the oven of range No. 3, with the glass door, would indicate high losses but due to its small size, and large heating units, the temperature increased rapidly.

The excellent heat retaining property of oven No. 6 is probably accounted for by the oven walls being well insulated and the door fitting close, as the ventilation permitted very little heat to escape.

In the determination of the efficiency of the oven the volume must be considered as well as its temperature. The curves in Fig. 11 represent the energy loss per cubic foot of oven space. The

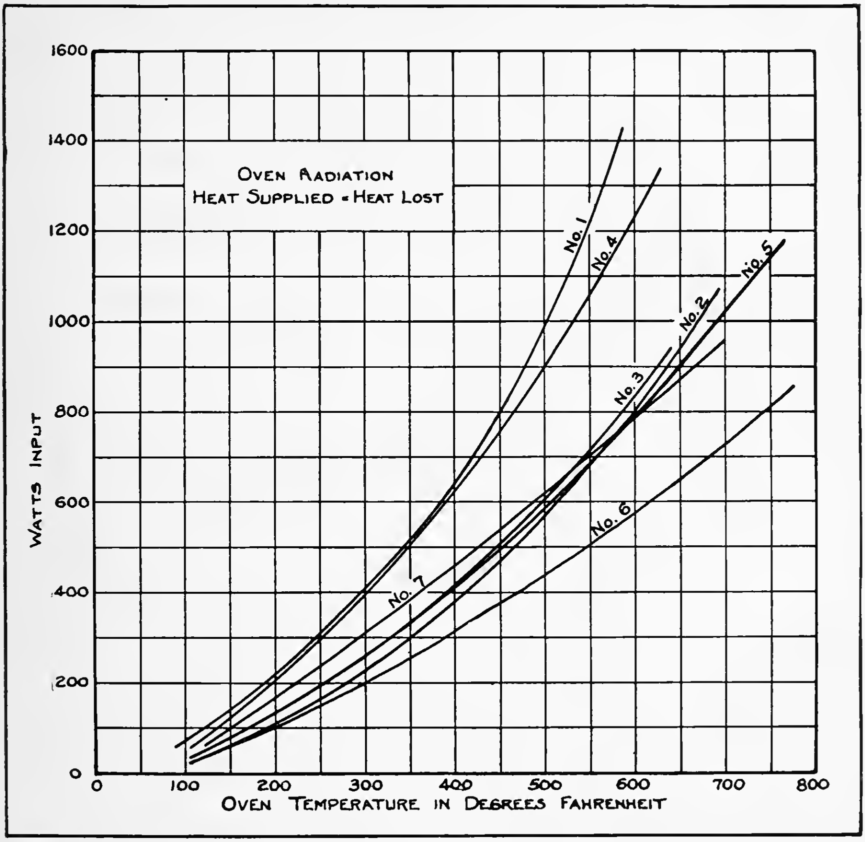


Fig. 10

ordinates are derived by dividing the watts input by the volume of each oven expressed in cubic feet. This gives the economic performance of each oven. Oven No. 3 has the maximum loss per cubic foot of contents, as would be expected from its construction. The other ranges fall in order as indicated by the cooling rates previously discussed.

## BAKING TESTS

The foods chosen were those consumed regularly in the home. They were selected with respect to the time required for baking. Biscuits require but a short time, bread and cake bake in about an hour, while meat consumes several hours.

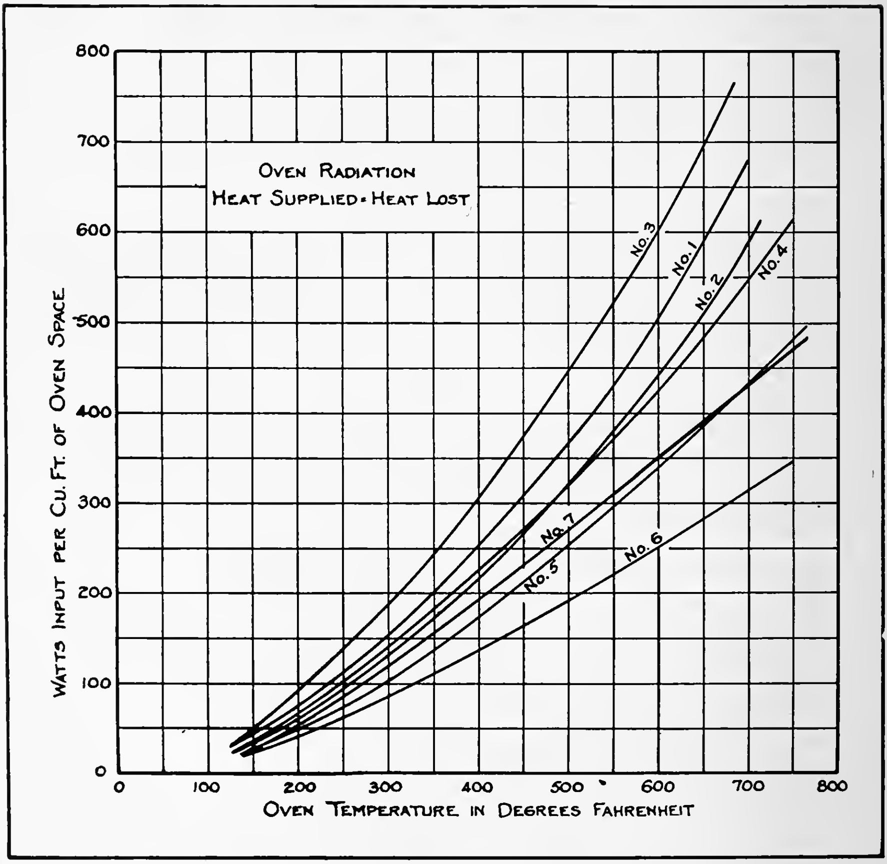


Fig. 11

The same person prepared the biscuits, cake, bread and meat, attended to their insertion and removal from the ovens and inspected their progress during baking. This method allowed those conducting the test to devote their entire time and attention to the many necessary instrument observations, and made for uniformity of manipulation.

### BISCUITS

The biscuits were baked in the ovens at an approximate temperature of 450°F. Observations were recorded at intervals of two minutes. The baking extended over a period of ten to twelve minutes.

One batch of dough was prepared, from which a pan of six biscuits was placed in each oven. This made the tests uniform and a comparison of results possible. Five tests were conducted in each oven.

### CAKE

Three cake bakings were run in each oven, each cake taking about sixty minutes at an approximate temperature of 350°F.

### BREAD

The bread baking was conducted in a similar manner to the foregoing tests, one batch of dough being prepared from which an equal amount was placed in each oven. The bread was in the oven for approximately seventy-five minutes, at a temperature of 375°F.

### MEAT

One meat roasting test was conducted in each oven. The roast was started at a temperature of approximately 475°F. During the three hours required to prepare the meat, the temperature was allowed to decrease to about 300°F.

## RESULTS OF BAKING TESTS

The results of the baking tests are given in Figs. 12 to 19. The continuous curves are for the oven temperature. Any adjustment of the control switch, or opening and closing of the oven door causes a lagging increase or decrease of the oven temperature; hence a gradual rise or fall in the temperature curve. The oven temperature for the bread and meat should decrease slowly as baking progresses as indicated in the curves.

The adjustment of the control switch produces an immediate increase or decrease of the power input, which is represented by the dotted line and accounts for its irregularity. When the oven is being used as a fireless cooker the power is turned off. During the baking some of the ovens require a large amount of power, while others use very little and often were operated as fireless cookers. Range No. 5 was operated as a fireless cooker most of the time.

The first test was started at the point marked "No. 1 in" and baking continued until the point marked "No. 1 out." The second test was prepared and started at the point marked "No. 2 in," thus the baking continued throughout the tests.

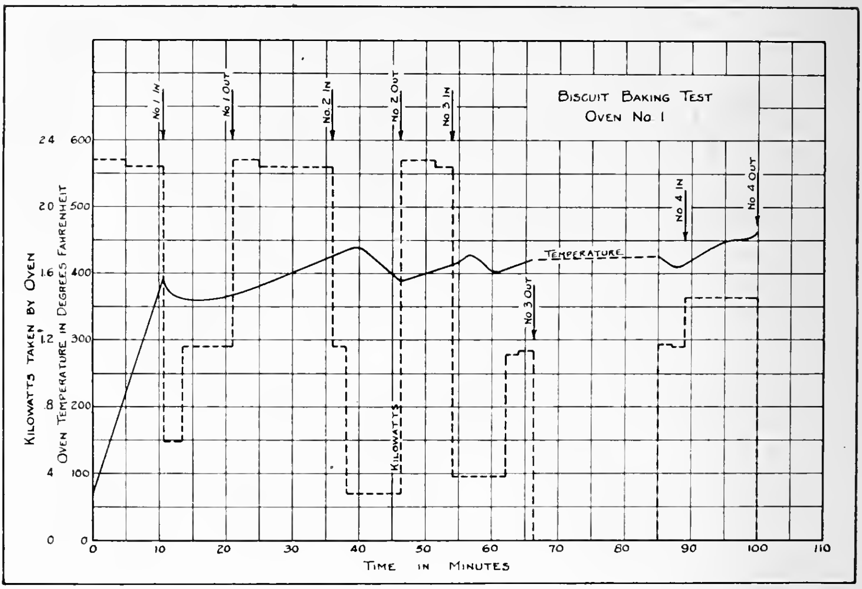
Biscuit Baking Test
Oven No. 1
No 1 In
No 1 Out
No 2 In
No 2 Out
No 3 In
No 3 Out
No 4 In
No 4 Out
Temperature
Kilowatts
Kilowatts taken by Oven
Oven Temperature in Degrees Fahrenheit
Time in Minutes

**Fig. 12**

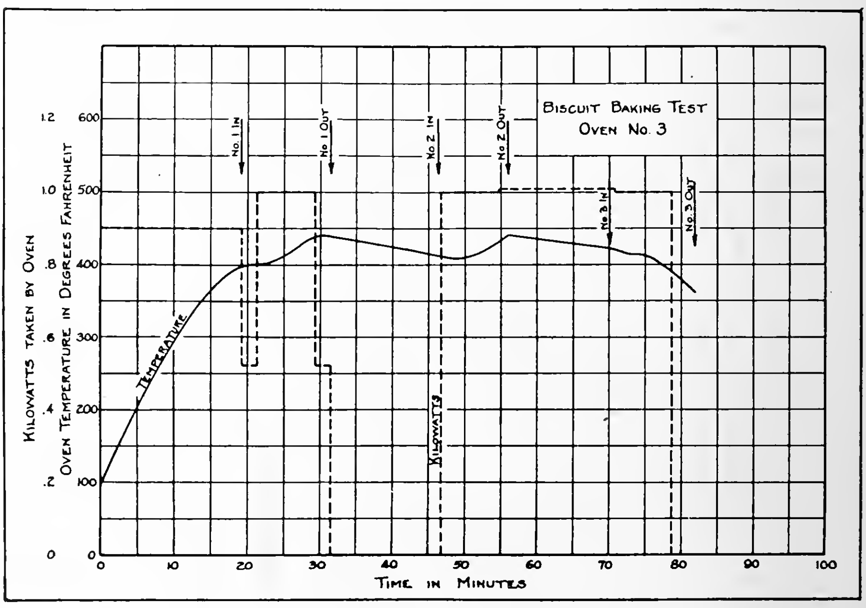
Biscuit Baking Test
Oven No. 3
No. 1 In
No 1 Out
No 2 In
No 2 Out
No 3 In
No 3 Out
Temperature
Kilowatts
Kilowatts taken by Oven
Oven Temperature in Degrees Fahrenheit
Time in Minutes

**Fig. 13**

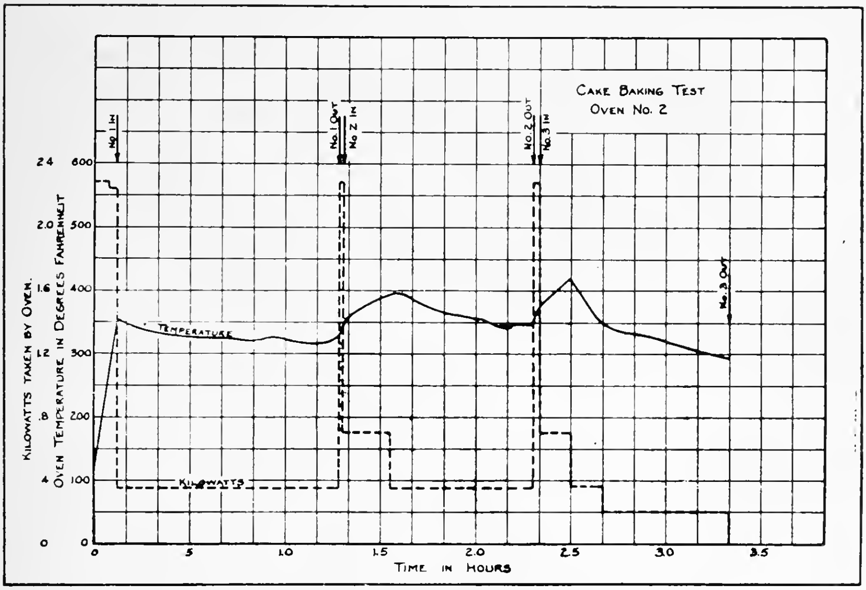
Cake Baking Test
Oven No. 2
No 1 In
No. 1 Out
No 2 In
No. 2 Out
No. 3 In
No. 3 Out
Temperature
Kilowatts
Kilowatts taken by oven.
Oven Temperature in Degrees Fahrenheit
Time in Hours

Fig. 14

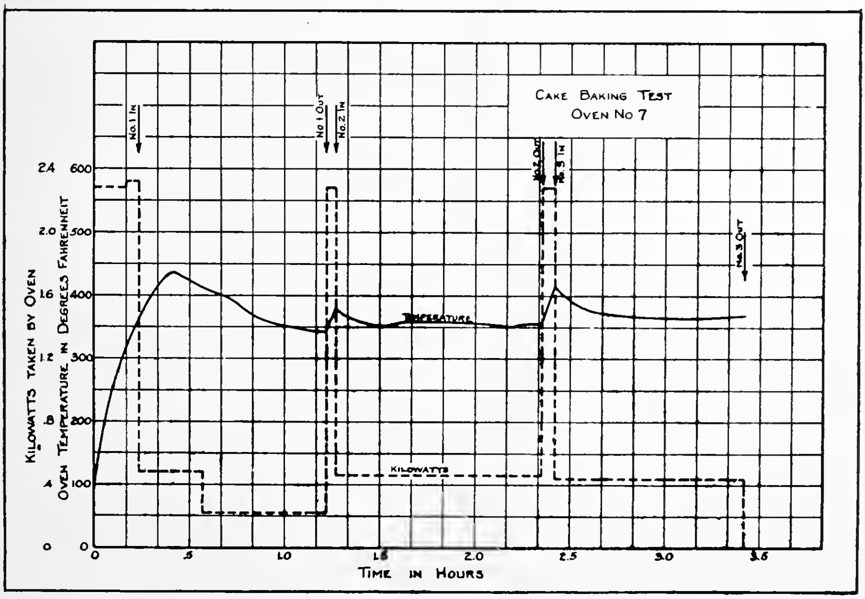
Cake Baking Test
Oven No 7
No. 1 In
No 1 Out
No. 2 In
No. 2 Out
No. 3 In
No. 3 Out
Temperature
Kilowatts
Kilowatts taken by Oven
Oven Temperature in Degrees Fahrenheit
Time in Hours

Fig. 15

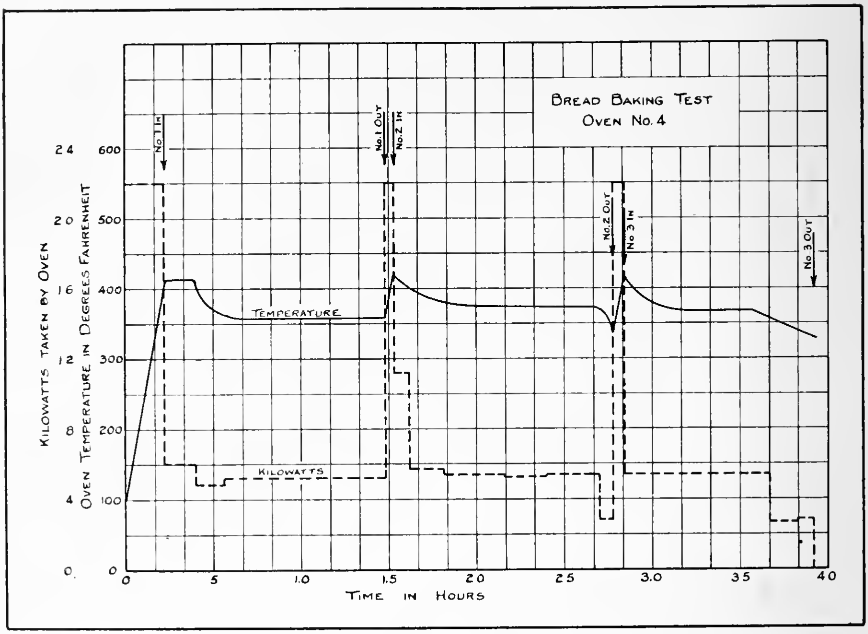
Bread Baking Test
Oven No. 4
No 1 In
No.1 Out
No.2 In
No.2 Out
No 3 In
No.3 Out
Temperature
Kilowatts
Kilowatts taken by Oven
Oven Temperature in Degrees Fahrenheit
Time in Hours

**Fig. 16**

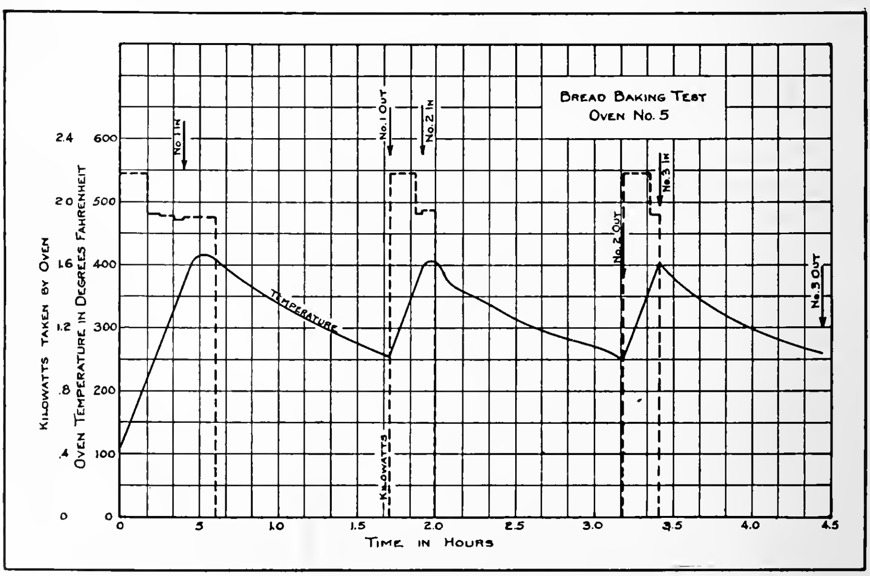
Bread Baking Test
Oven No. 5
No 1 In
No.1 Out
No.2 In
No.2 Out
No.3 In
No.3 Out
Temperature
Kilowatts
Kilowatts taken by Oven
Oven Temperature in Degrees Fahrenheit
Time in Hours

**Fig. 17**

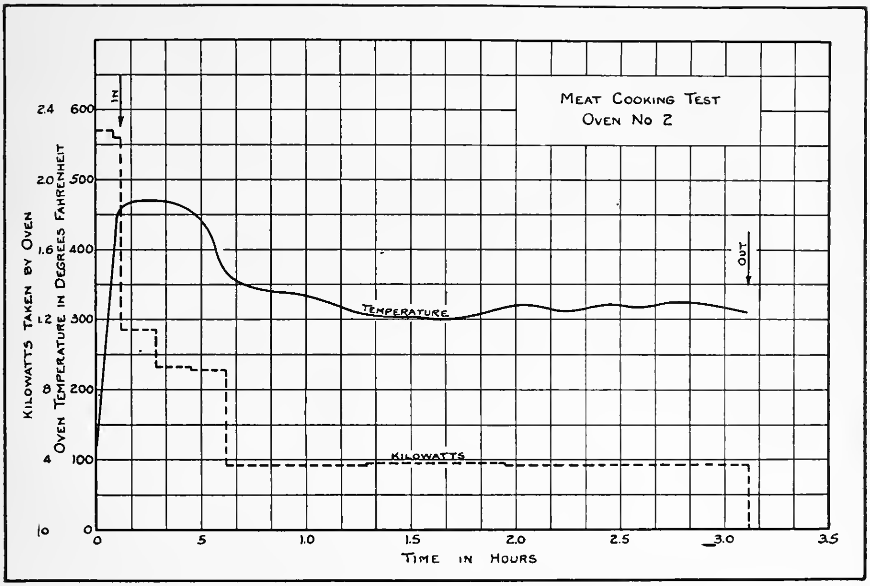
Meat Cooking Test
Oven No 2
Kilowatts Taken by Oven
Oven Temperature in Degrees Fahrenheit
2.4 600
2.0 500
1.6 400
1.2 300
.8 200
.4 100
0 0
IN
OUT
Temperature
Kilowatts
0
.5
1.0
1.5
2.0
2.5
3.0
3.5
Time in Hours

**Fig. 18**

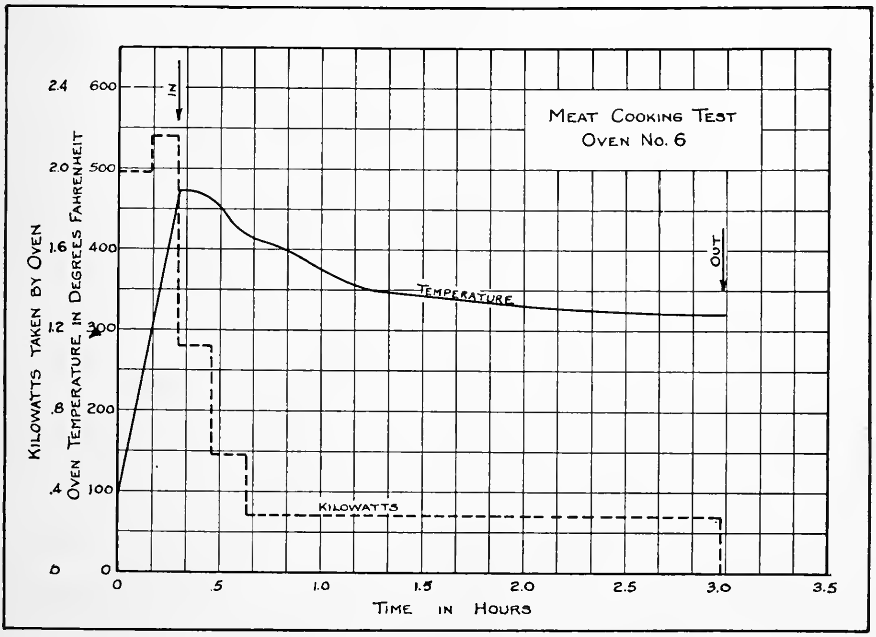
Meat Cooking Test
Oven No. 6
Kilowatts Taken by Oven
Oven Temperature in Degrees Fahrenheit
2.4 600
2.0 500
1.6 400
1.2 300
.8 200
.4 100
0 0
IN
OUT
Temperature
Kilowatts
0
.5
1.0
1.5
2.0
2.5
3.0
3.5
Time in Hours

**Fig. 19**

## MISCELLANEOUS OBSERVATIONS

The method of operating the ranges was similar in every case.

Individual taste, difference in ovens and variation in voltage of the supply circuit, all tend to produce a variable time temperature curve. Thus the curves given for the time and temperature of baking Figs 12 to 19 are only suggestive.

Ovens No. 1 and No. 2 required more heat than the others. It was probably because their radiation was great and their loss of heat large when doors were opened. It did not increase the cost of operating materially, as it takes a very short time to get the ovens hot.

The oven of range No. 3 was just large enough for the small size roaster, and so shallow that the bread almost touched the top coil. When roasting meat, this was the only oven in which steam condensed and ran out around the door. This condensing might have been caused by the cool glass in the oven door.

In oven No. 4 the food had to be turned so as to brown evenly, probably because of improper location of the heating coils.

Oven No. 5 was steam tight and held heat longest, but upon opening the oven door, the fumes of the fat from the roasting meat, and the intense heat were very disagreeable to the face and eyes. The flavor of the meat roasted in this oven was not nearly as good as the other roasts, due to the tight oven, not permitting the vapor to escape.

The ovens after being heated, did not need both the upper and lower coils energized, the lower coil only being used most of the time. The upper coil was used only when baking was nearly complete, so as to give the desired brown to the food.

During most of the baking operations, the ovens could have been operated partially as fireless cookers. They are so constructed as to economize in power in that way. The current also might have been turned off a few minutes before the food was entirely cooked and finished as in a fireless cooker. The better one understands the ranges, the more economical will their operation become.

## SURFACE BURNERS

Four types of surface burners were studied.

Ranges Nos. 2, 4 and 6, were equipped with moulded porcelain burners. These are round flat porcelain plates with deep grooves in their upper surfaces to receive the heating coils. This type of burner transfers the heat more by conduction than by radiation.

The open coil reflector burner on Range No. 1 has the coils mounted in a steel frame, supported with porcelain bushings in truss construction. A bright reflector is located underneath to assist in concentrating the heat upon the cooking utensils. The heat is transferred to the vessel principally by radiation and convection.

Fig. 20. Porcelain type surface burners.

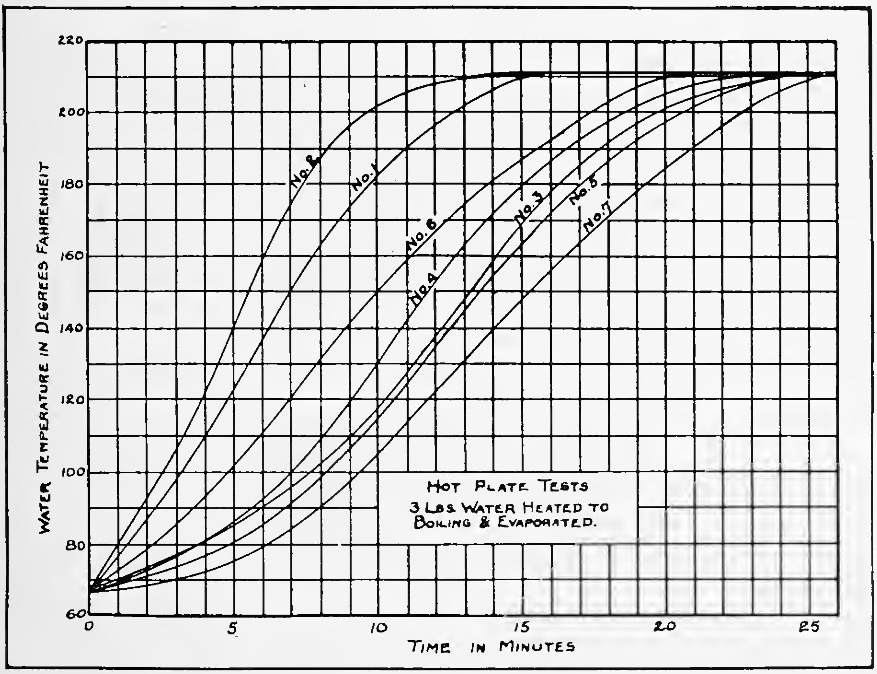


Fig. 21

The semi-enclosed unit of range No. 7 is of the moulded porcelain construction. The element is separated from the vessel by a cast steel grating. Heat must be carried largely by convection for about three quarters of an inch to the grating, then by conduction to the utensil.

The enclosed or iron-clad unit has its coils entirely within a steel jacket, which presents a smooth surface to the vessel. Ranges Nos. 3 and 5 have this type of surface burner. They are very efficient with metal ware, as the heat is transferred directly by conduction.

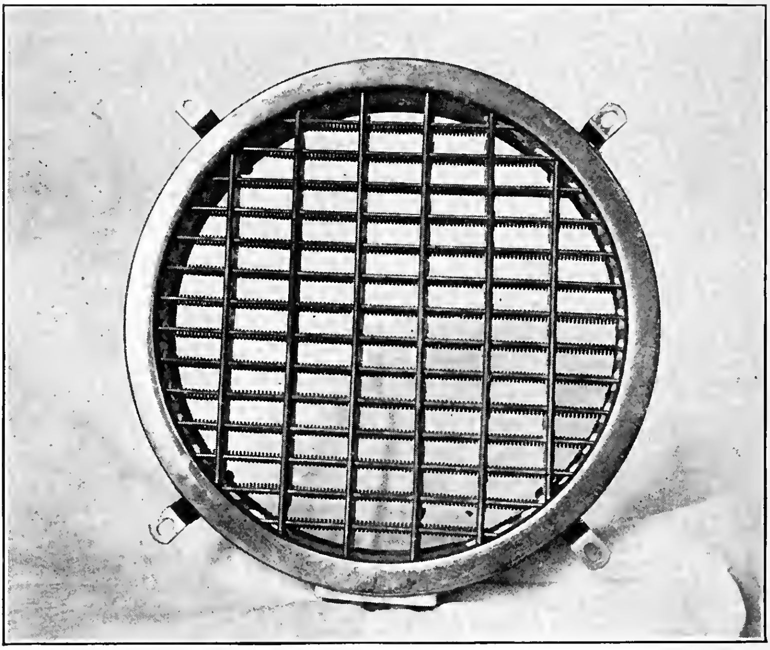

**Fig. 22. Open coil reflector type surface burner.**

## SURFACE BURNER TESTS

The tests were conducted under laboratory conditions such as constant voltage and the elimination of cool air currents from the room. A known amount of water was evaporated and the input noted. A vessel was selected that would just cover the hot plate. This was a dark granite straight side pan, eight inches in diameter and six inches high, with a bulge upward in the bottom, of about three-eighths of an inch. Three pounds of water were used in each test and evaporated down to the top of the bulge. The weight of the remaining water, subtracted from the three pounds, gave the amount evaporated. The change of temperature was noted at five-minute intervals up to the boiling point. The temperature increased rapidly to 205°F. and very slowly from this point to 212°F. It was difficult to determine the exact time that the water arrived at the boiling point. Due to this fact no calculations have been made involving the boiling point. Efficiencies have been calculated for the total boil-

ing period and for the first eight minutes of the heating period. Fig. 21 shows the time required to heat three pounds of water to the boiling point on each of the seven ranges.

The thermal efficiency was obtained by comparing the British thermal units absorbed by the water, with the British thermal units put into the burner.

The following relations are stated in order that the method of determining the thermal efficiencies may be evident.

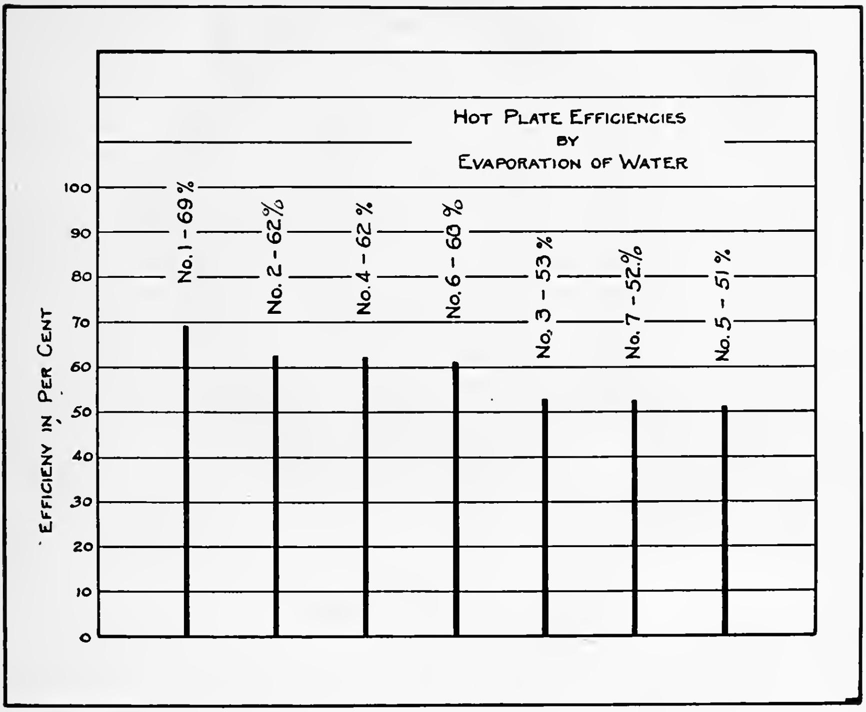


Fig. 23

To raise the temperature of one pound of water one degree Fahrenheit, one British thermal unit is required.

To evaporate one pound of water at 212°F. requires the absorption of 969.7 British thermal units.

One kilo-watt-hour is equivalent to 3415 British thermal units.

The efficiencies as shown in Fig. 23, were obtained by adding to the product of the temperature change and total weight of water, the British thermal units obtained by the product of 969.7 and the weight of water evaporated, expressed in pounds. This sum was then divided by 3.415 times the watt hours used.

T = Temperature of water at start of test.
T′ = Temperature of water at end of test.
W = Total weight of water in pounds.
W′ = Total weight of water evaporated in pounds.
WH = Watt hours put into the burner.

$$\frac{(T'-T)\ W + 969.7\ W'}{3.415\ (W.H.)} = \text{Efficiency}$$

The efficiency at the end of the first eight minutes, at a point below the boiling temperature on each range, was obtained in a similar manner. Fig. 24 shows the hot plate efficiencies for three pounds of water heated for eight minutes.

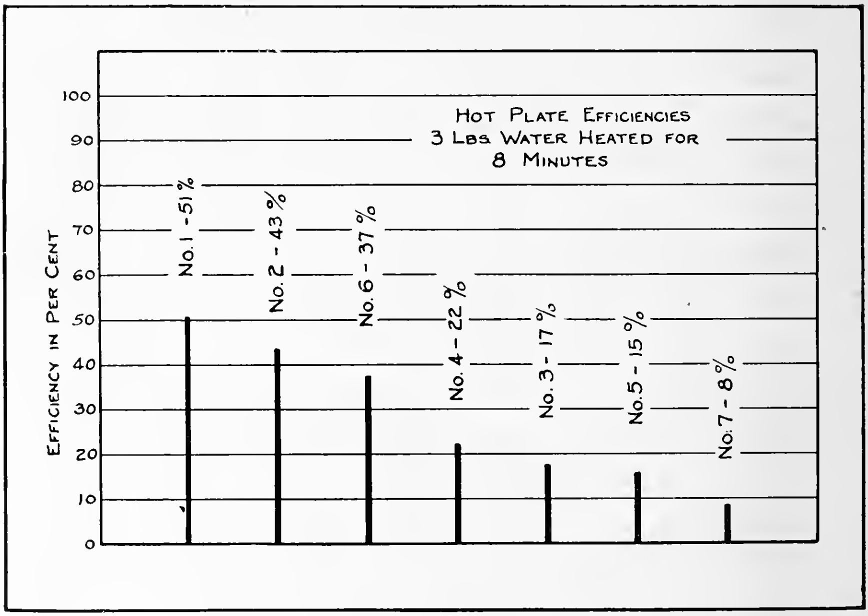


Fig. 24

## THE BURNERS

The grooves of the moulded porcelain burner form deep pockets in which the food lodges. This has to be burned or dug out to prevent the burner from becoming hot in spots and being damaged.

The open-coil reflector burner, to maintain its high efficiency depends upon the reflector being kept bright. Particles of food drop through and lodge upon the reflector. This, together with the intense heat, cause a loss of reflecting properties which lowers the efficiency rapidly.

The semi-enclosed burner is very difficult to keep clean.

The enclosed burner is expensive to operate for short periods and takes more time and energy for heating.

The radiant reflector type is most efficient in the laboratory where conditions are under better control and where the reflector can

**Fig. 25. Semi-enclosed type surface burner.**

be kept bright by frequent changes. With burners such as this in the home, the efficiency might soon drop below that of the porcelain type.

The porcelain burner maintains a high efficiency without much attention.

For long periods of heating the iron-clad and semi-enclosed units are best adapted and are very efficient.

## THE RELATIVE COST OF BAKING

The following tables give the results of the various tests upon the seven electric ovens. The three cent kilowatt-hour rate was used in computing the costs.

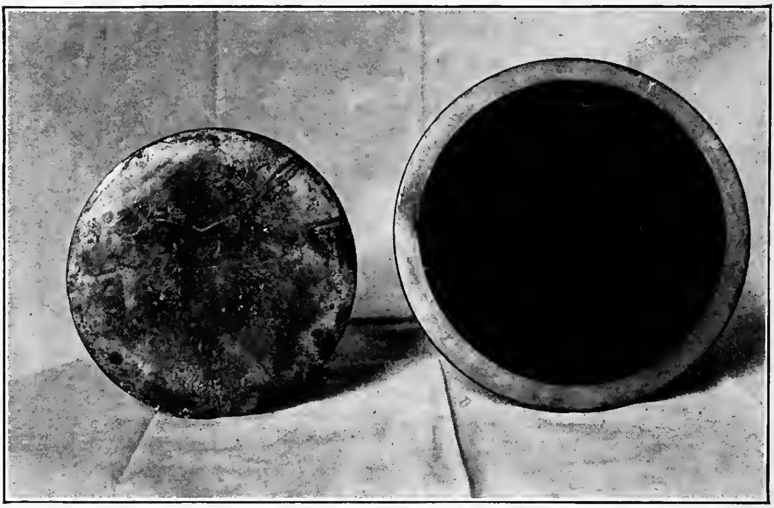

Fig. 26. Enclosed type surface burners.

### BISCUITS

| Stove No. | Preheating watt hours | Preheating time min. | Number of tests | W. H. to bake | Percent of total w. h. to bake | Total w.h.pre-heating & baking | Total cost cents |
|---|---|---|---|---|---|---|---|
| 1 | 558 | 15 | 4 | 178 | 24 | 736 | 2.2 |
| 2 | 547 | 12 | 4 | 194 | 26 | 741 | 2.27 |
| 3 | 891 | 50 | 3 | 128 | 12 | 1019 | 3.0 |
| 4 | 929 | 20 | 4 | 111 | 10 | 1040 | 3.1 |
| 5 | 1677 | 38 | 5 | 150 | 8 | 1827 | 5.4 |
| 6 | 1075 | 21 | 5 | 116 | 9 | 1191 | 3.5 |
| 7 | 961 | 25 | 4 | 137 | 12 | 1098 | 3.3 |

Oven No. 1 cost less for biscuits, while No. 5 proved to be the most expensive. The heating units in oven No. 1 were of the open type and the ventilated oven was lined with bright aluminum. The heat units of No. 5 were of the enclosed type, imbeded in heavy cast steel. The oven was lined as No. 1 but was not ventilated.

Biscuit baking is a short process, requiring but twelve minutes. It is evident that ovens constructed as that of No. 1 with the open type heating unit are the most economical for short period baking, owing to their quick preheating characteristic.

### CAKE

| Stove No. | Preheating watt hours | Number of tests | Watt-hours to bake | Percent of total w.h. to bake | Total watt hours preheating & baking | Total cost cents |
|---|---|---|---|---|---|---|
| 1 | 558 | 3 | 885 | 61 | 1443 | 4.3 |
| 2 | 547 | 3 | 356 | 39 | 903 | 2.7 |
| 3 | 891 | 3 | 322 | 24 | 1303 | 3.9 |
| 4 | 929 | 3 | 458 | 33 | 1387 | 4.1 |
| 5 | 1677 | 4 | 326 | 16 | 2004 | 6.0 |
| 6 | 1075 | 4 | 360 | 25 | 1435 | 4.3 |
| 7 | 961 | 3 | 412 | 30 | 1375 | 4.1 |

Oven No. 2 was a little cheaper for cake baking than oven No. 1. Their construction is similar. Oven No. 5 was again the most expensive.

### BREAD

| Stove No. | Preheating watt hours | Watt hours to bake | Percent total w.h. to bake | Total watt hours preheating & baking | Total cost cents |
|---|---|---|---|---|---|
| 1 | 558 | 576 | 51 | 1134 | 3.4 |
| 2 | 547 | 346 | 35 | 893 | 2.6 |
| 3 | 891 | 362 | 39 | 1253 | 3.7 |
| 4 | 929 | 591 | 39 | 1520 | 4.5 |
| 5 | 1677 | 32 | 2 | 1710 | 5.1 |
| 6 | 1075 | 288 | 21 | 1363 | 4.0 |
| 7 | 961 | 423 | 30 | 1384 | 4.1 |

Three bread baking tests were run in each oven. They were similar to those of the cake. The time required was about the same in both cases, being seventy-five or eighty minutes. The small input for bakin, to oven No. 5 was due it its use as a fireless oven most of the time.

### MEAT

| Stove No. | Preheating watt hours | Watt hours to bake | Percent total w.h. to bake | Total watt hours preheating & baking | Total cost cents |
|---|---|---|---|---|---|
| 1 | 558 | 2224 | 81 | 2782 | 8.3 |
| 2 | 547 | 1315 | 71 | 1862 | 5.5 |
| 3 | 891 | 1169 | 57 | 2060 | 6.1 |
| 4 | 939 | 1299 | 58 | 2228 | 6.6 |
| 5 | 1677 | 499 | 23 | 2177 | 6.5 |
| 6 | 1075 | 143 | 12 | 1218 | 3.6 |
| 7 | 961 | 1974 | 67 | 2935 | 8.8 |

The longer baking tests, such as with the meat, rather reverse the conclusions derived from the short tests. Oven No. 1 was best for short baking periods, while it was about the most expensive for cooking of long duration. The heavy enclosed type of

heating unit and ovens of the type of No. 5 were found to be the cheapest for long periods of baking. They are the most expensive for quick baking.

The comparative costs of operating the electric ranges are given in Fig. 27.

The energy required to preheat the ovens is large as compared with that put into the ovens for baking. Thus the quantity of food could be increased for larger families without the same proportionate increase in cost.

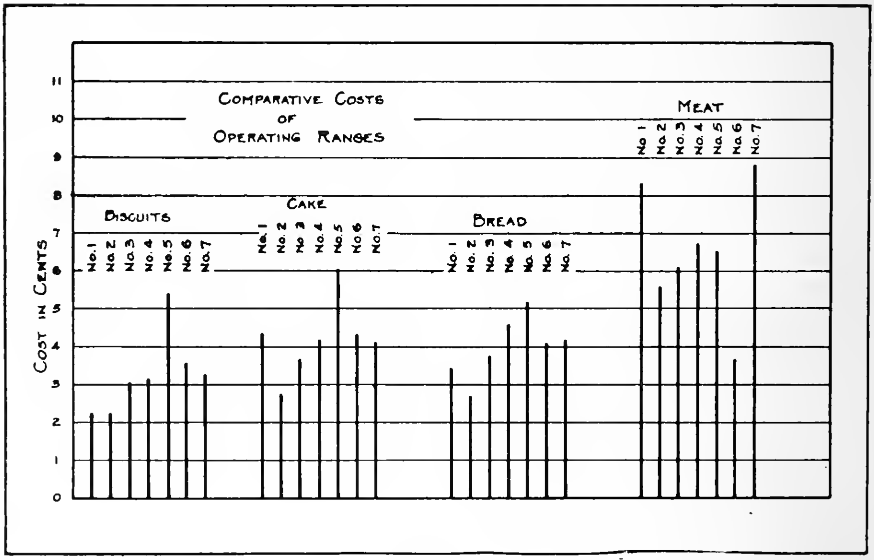


Fig. 27

An oven selected for the home should be one suitable for short baking periods as with few exceptions food prepared in the home requires less than one hour for baking. It should have a well insulated, light aluminum lining and adjustable ventilation. Open type heating units are most desirable.

Service such as restaurants, hotels, clubs, etc., where the ovens will be in service for long periods and quite frequently, the heavy cast steel enclosed, heating unit would be by far the most economical.

## ELECTRIC RANGE DATA

The cost of operating the electric range in the home, together with the characteristic range load curve, have been studied by several of the large power companies, so as to make the proper adjustment of energy rates.

Mr. Henry Wallsmith, Hartford City, Indiana, in his report* to the American Gas & Electric Company, shows some very interesting facts in regard to electric range performance for different size families and homes.

The rate paid for electricity is a combination cooking and lighting rate; lighting rate eleven cents per K. W. H., cooking rate six cents per first ten K. W. H., and all excess consumption three cents per K. W. H.

| Size of family | Number of rooms | Time month & day | Range k.w.h. | Light k.w.h. | Total k.w.h. | Total bill | Net Range bill |
|---|---|---|---|---|---|---|---|
| 2 | 6 | 1-14 to 2-21 | 36 | 11 | 47 | $2.29 | $1.19 |
| 2 | 6 | 3-24 to 4-24 | 71 | 11 | 82 | 3.26 | 2.16 |
| 3 | 7 | 1-22 to 2-21 | 112 | 20 | 132 | 5.06 | 3.06 |
| 5 | 6 | 3-22 to 4-22 | 54 | 58 | 112 | 4.24 | 1.56 |
| 5 | 8 | 2-23 to 3-24 | 101 | 32 | 133 | 5.31 | 2.11 |
| 7 | 10 | 2-21 to 3-21 | 108 | 51 | 159 | 6.53 | 1.43 |
| 7 | 10 | 12-22 to 1-22 | 167 | 57 | 218 | 8.30 | 2.60 |

The Pacific Power & Light Company reports† a detailed investigation into the cost of cooking by electricity. The results obtained from the investigation indicate that the average family can cook electrically for about $3.00 per month with energy selling at 3.6 cents per K. W. H. The company has a total of 201 electric ranges connected to its lines.

The average monthly number of ranges in service was 161, with a yearly cost for operating each range of $30.60. The average monthly bill was $2.55 net. The company has deducted from the total, all the minimum charge bills and their earnings and finds that the average bill now is $3.13 a month. This is a more accurate expression of the cost of electric cooking, because the minimum charge bills do not indicate that the ranges were really used to their best advantage.

A New England Power Company which has sixty ranges connected to its lines, and a rate of three cents per K. W. H., reports‡ an average cost of eighty cents per month per person as a fair cost of preparing meals electrically.

The cost of baking electrically as presented by this bulletin can not be stated in terms of cost per person per month as this includes cooking with both surface burners and ovens.

* N. E. L. A. Bulletin
† Electrical World, January, 1919
‡ N. E. L. A. Bulletin

## CHARACTERISTICS OF RANGE LOAD

The opinion of many engineers is that the peak of the range load occurs at the same time as the station peak and that the maximum range demand will be a large percentage of the range connected load. Mr. R. B. Snyder of the Milwaukee Electric Railway & Light Company, in his analysis of the electric range load found several conditions which are interesting to note.*

The demands upon the gas supply for the average city, where most of the homes use this fuel for cooking, occurs at the noon hour. These are the consumers who will eventually use electricity, so their maximum demand will no doubt be at the same hour.

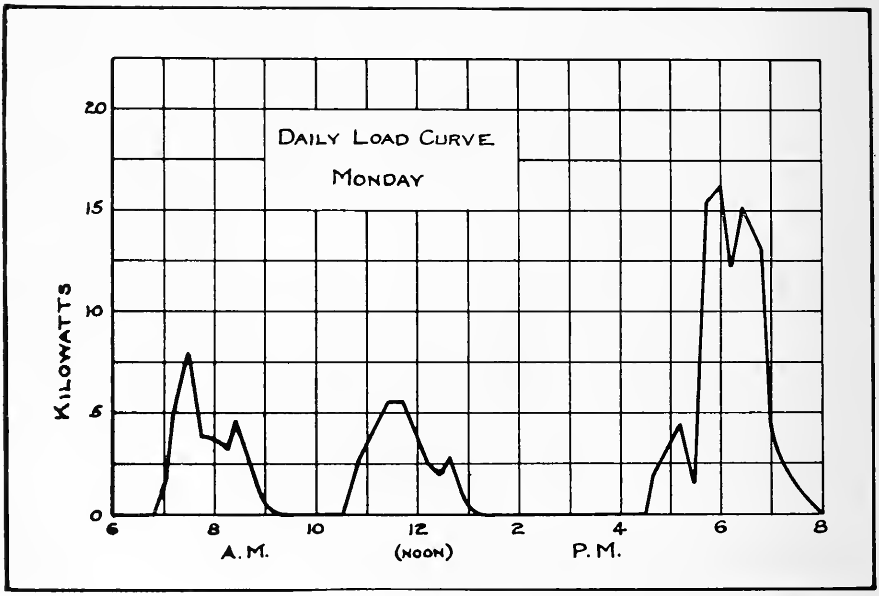


Fig. 28 4

The demand from the apartment buildings seems to be of a different character. The average daily load for an apartment with twenty-two electric ranges in service, gives the curves of Figs. Nos. 28 and 29 with the peak in the evening from 5 p. m. to 6:30 p. m.

The distribution of electric ranges between ordinary homes and apartment buildings results in a distinct advantage to the company furnishing the power supply. With the range load thus divided, two peaks occur in the range load curve, instead of a single one. These peaks appear at from 11:30 A. M. to 1:00 P. M., and from 5:00 P. M. to 6:30 P. M.

* Electrical World, April 14, 1917

The curves indicate further that the demands for each week day was about the same. The maximum was 22 K. W., with Sunday a minimum of 9 K. W. The total connected load was 98 K. W. The maximum demand for a group of twenty-five ranges will not exceed fifteen percent of the connected load. The maximum demand for a single range may averge 40 to 60 percent of its rating.

The average daily consumption per person over a period of ten days was 1.18 K. W. H., including lights. This shows the average consumption to be well below 1 K. W. H. per person per day.

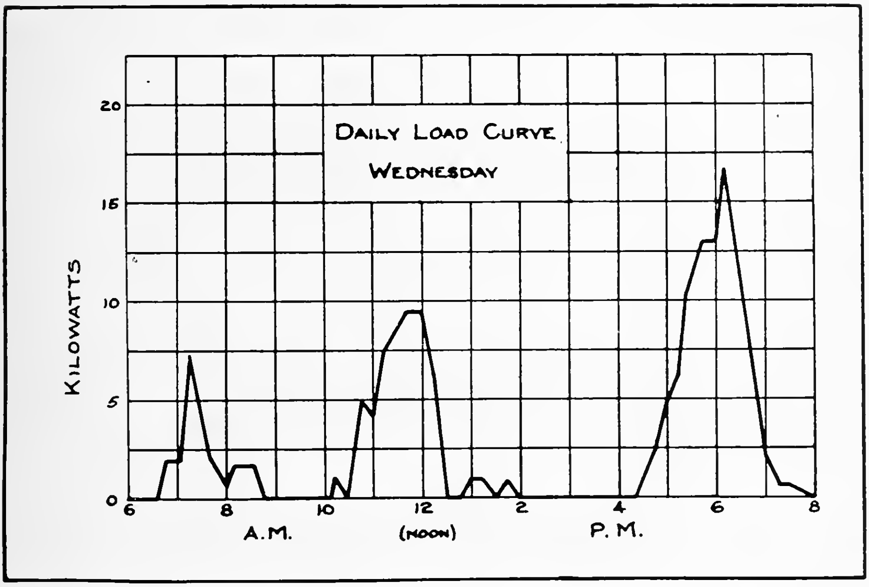


Fig. 29

## THE ADVANTAGES OF ELECTRIC RANGES

The possibilities of using electricity extensively for cooking purposes are rapidly being recognized in all parts of the country.

The gas stove is gradually being replaced by the electric range. This replacement will continue unless a gas stove can be produced which will duplicate the results obtainable with the electric range.

Undoubtedly the electric range will maintain its superiority. It will do that which the ordinary gas range will do and in addition is more sanitary and does better cooking, due to the fact that there is less shrinkage. Edibles do not become dried out as in the gas range and the results are more like the coal range.

Gas is more generally used in the cooking field today solely because it is at present cheaper than electricity. However, electricity is constantly becoming cheaper, and has reached such a figure in many parts of the country that many electric stove companies are earning good dividends.

There can be no question about the advantages of electricity over gas or coal, for heating and cooking purposes. It is convenient. All that is necessary to start the cooking operation is to snap a switch or press a button. It is cleanly, it causes no smoke, soot, noxious gas, ashes or dirt. It is labor saving in that it eliminates dirt from pots and pans. It is safe in that there is no danger of fire from

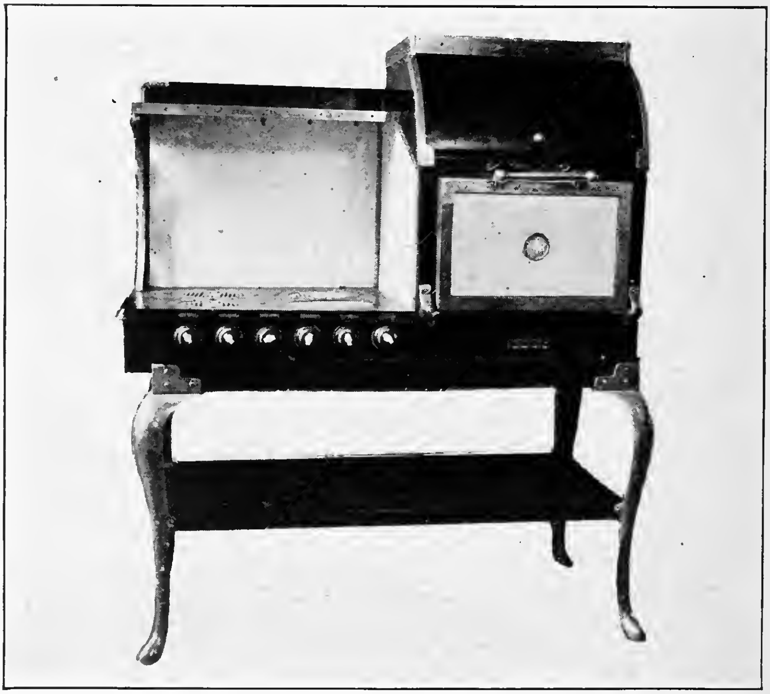

**Fig. 30. Range No. 4. Surface burners, porcelain type. Oven heating units, enclosed and open type.**

gases. It can be easily regulated to produce a steady even heat at any desired temperature, by the upper and lower heating units having three controls each, giving eighteen different oven temperatures.

The automatic attachments which can be placed upon electric ranges are desirable as well as economical. The clock, thermastat,

and fireless cooker arrangement enable one to place the meal in the oven at their convenience, setting the clock and thermostat with the knowledge that the energy will be turned on at the proper time and continue until the oven is of the desired temperature, then the thermostat will stop the current flow and the meal will be prepared by the fireless cooker method at the proper time.

Five principal reasons have been paramount in the delay of the general public in taking up electric cooking.

They may be enumerated as follows:

1. High first cost including purchase price and installation.
2. Anticipated high operating cost.
3. Satisfaction with present method of cooking.
4. Loss in disposition of old equipment.
5. Slightly longer time for cooking.

All these reasons are rapidly being overcome. Central stations are doing their utmost to cheapen installations by introducing low prices and deferred payments.

## POINTS TO BE CONSIDERED IN SELECTING AN ELECTRIC RANGE

The desirable characteristics as developed during the tests are indicated below. Most of the ranges tested met these requirements very well.

In general an electric range should be:
Attractive in appearance;
Easy to clean;
Provided with heating units separately controlled.

Surface burners should have:
Porcelain heating units;
Heating units of different sizes.

The oven should be:
Quick heating;
Ventilated;
Of convenient height and size;
Designed to give uniform browning of foods.

The heating elements should be easily removable for repairs or cleaning. The moulded porcelain types of coils are desirable as they heat quickly and one can tell readily when the current is on. Open coils are best for the oven.

Surface or hot plate elements of different diameters are desirable. Such elements accommodate cooking vessels of different sizes and thus save much energy.

The oven should be non-rusting, well insulated, and provided with a substantial, close-fitting door. The steam tight oven is not

desirable because food will not brown until extra energy is used to eliminate the moisture.

Ovens raised from the floor are more convenient. The glass door is more economical, because there is less necessity for opening the door, resulting in loss of heat. The glass is, however, liable to be broken when hot, by a little cool air striking it. Pyrex glass used in the door would probably remedy this defect.

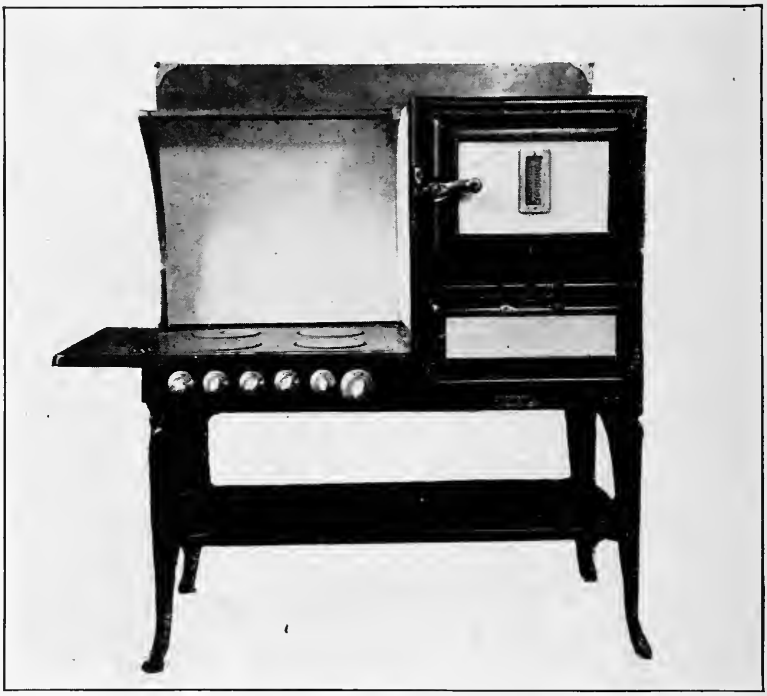

**Fig. 31. Range No. 5. Heating units enclosed type.**

A right hand oven with a door that opens down is most convenient.

The oven should have a dependable thermometer or temperature indicator.

Each element should be individually fused and should have a separate switch. This would prevent the whole or a large portion of the stove being rendered inoperative by accident to a single unit.

Ample capacity in burners is to be desired, so that delays may be reduced to a minimum.

The inside dimensions of the oven should be about eighteen inches wide, twelve inches high, and sixteen inches deep.

## DESCRIPTION OF RANGES

The size of the oven as stated represents the size of the largest receptacle it will accommodate and not the outer dimensions given by some of the manufacturers.

The four surface burners of range No. 1 are of open construction and of different diameters. The oven is eighteen and one-half

**Fig. 32. Range No. 6. Surface burners, porcelain type. Oven heating units, porcelain and open type.**

inches wide, ten inches high, and eighteen inches deep, with two large open heating units, each taking 1200 watts. The oven is ventilated.

There is no heat insulation between the bottom of oven and warmer oven which is just below. The door does not fit tightly and opens downward. There is a metal thermometer in the door.

Range No. 2 has three surface burners of moulded porcelain of the same diameters. The oven is eighteen inches wide, fourteen inches high and twelve inches deep, with two large open heating units, each consuming 1250 watts. The oven is well insulated and ventilated. The door fits tightly and opens downward. There is a metal thermometer in the door.

The two surface burners of Range No. 3 are enclosed, both being eight and one-half inches in diameter. The oven is nineteen inches wide, ten and one-half inches high and twelve inches deep, provided with two large open heating units using 1000 watts each. It is well insulated and ventilated. The door, with glass panels, opens from the side. The oven is equipped with a metal temperature indicator and automatic clock current control.

Range No. 4 has four surface burners of open porcelain. Three are six and one-half inches in diameter, one eight and one-half inches in diameter. The oven is eighteen and one-half inches wide, fifteen inches high and twelve inchest deep, with two large heating elements. The upper one is open and the lower one enclosed, both together taking 2500 watts. The oven is not ventilated. The door is poorly fitted and opens downward. There is a metal thermometer in the door.

The surface burners of range No. 5 are enclosed, one eight inches in diameter and three, six inches in diameter. The oven is eighteen inches wide, twelve inches high, and eighteen inches deep, with two large enclosed heating units, taking 3500 watts total. The oven is well insulated but not ventilated. There is a mercury thermometer in the door.

Range No. 6 has three surface burners of the open type. One is nine inches in diameter, the other two, seven and one-half inches in diameter. The oven is fifteen inches wide, thirteen inches high and eighteen and one-half inches deep, with two large heating units, taking 1000 watts each. The upper heating unit is of open construction, the lower, porcelain construction. The oven is ventilated, and equipped with a metal thermometer and automatic clock current control. The door fits tightly and opens from side.

Range No. 7 has three surface burners that are of the semi-enclosed type. One is six inches in diameter,—the other two are eight inches in diameter. The oven is eighteen inches wide, ten inches high and seventeen inches deep, with an open type upper heating unit and enclose lower unit, each using 1250 watts. It is well insulated and ventilated. The door fits well and opens downward. There is a metal thermometer in the door.

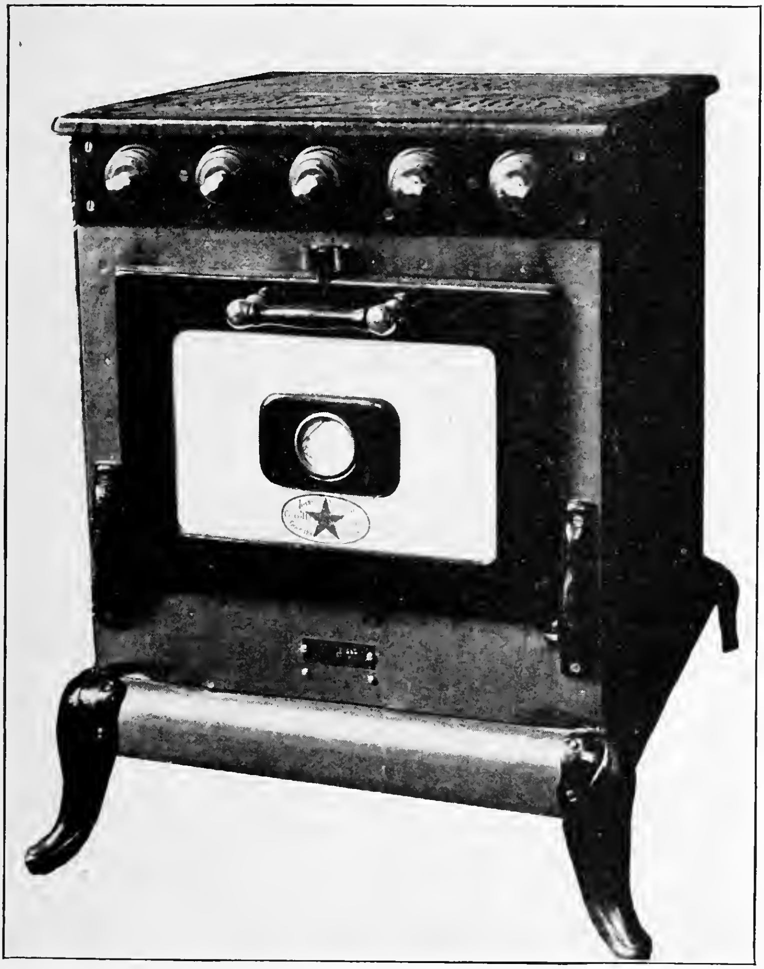

Fig. 33. Range No. 7. Surface burners semi-enclosed type. Oven heating units, enclosed and open type.

## CONCLUSIONS

The modern electric range has improved ventilation, resulting in more efficient application of heat. The surplus moisture is carried off and but little heat escapes. Meat, bread, cakes, and pies brown evenly to any degree on top, bottom and sides.

There is no need of matches.

There are no odors from gas or smoke. The kitchen is not hot.

There is no fire to use up the air in the room.

There is no scouring of pots and pans, so much time and labor are saved.

The electric oven is always ready and does its work with economy, cleanliness and little supervision.

The main obstacle which tends to restrict the use of electric ranges seems to be their price and the high rate of electric energy. If the rates were lowered, so that the operating expense would be the same as for other fuels, the added advantages of more leisure time, less labor and clean, sanitary methods would be obvious. These advantages should be taken into account when considering electric ranges, together with the fact that the insurance rate is usually reduced where gas is not taken into the home.

Statistics* show that there are more homes in the United States already which are supplied with electric current, than are supplied with running water. Thus it seems that further publicity and the introduction of special cooking rates will bring about the general use of electricity for cooking purposes.

The electric range is just beginning to receive the recognition which it deserves, being superior both to the coal and the gas range. A far higher percentage of the heat energy is absorbed by the food in the cooking and baking operations and very little goes into the kitchen to make it uncomfortably warm in hot weather.

The uniform results that can be obtained with the electric oven and the hot plates are appreciated by those who have used both gas and electric ranges.

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* Encyclopedia Britannica

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